MOBILE LIDAR: THE BENEFITS TO AIRPORTS FROM AN OPERATIONS AND SAFETY PERSPECTIVE

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ABSTRACT

In 2007, the Federal Aviation Administration (FAA) approved the use of airborne lidar (light detection and ranging) in conjunction with aerial imagery that is collected concurrently to perform obstruction surveys following FAR Part 77. There are many derivative data sets to airborne lidar; including, but not limited to, accurate 3D Digital Elevation Models (DEMs), accurate 3D Digital Surface Models (DSMs), identification and digitization of markings on runways and taxiways, and building locations, all of which could be utilized for beneficial purposes in airport planning, safety and operations.

At the same time in 2007, mobile lidar was being promoted as the next wave of lidar technology from global lidar manufacturers. These systems, which are mounted to a ground vehicle in various configurations, are able to capture large amounts of data in short periods of time while maintaining a high level of detail, precision and accuracy.

This paper focuses on the benefits of employing mobile lidar technology, to enhance airport and airfield knowledge, planning and operations, specifically to include but not limited to marking effectiveness, asset extraction and low/no visibility navigation.

Case studies from airports will be used to illustrate the opportunity to employ mobile lidar and related sensing technologies towards significant operational and safety benefit.

INTRODUCTION

Airports continue to evolve. From small, general aviation airfields, to large, international hubs, all airports are looking for more effective and efficient ways to operate and to better understand the complex environments. This involves decision-making on behalf of many entities of the airport. To do this, one must draw upon accurate, and reliable information in order to make an informed decision. A large component of airport information is spatially related. For example, knowing the locations of each navigation aid, understanding the drainage pattern of the Airport Operation Area, knowing how to best navigate the airfield to reach the scene of a potentially life-threatening incident, and detailed knowledge of the factors affecting a runway extension are just a very few items that are better understood when employing a geo-spatial perspective. Simply stated, all airports have a need for geospatial information. Therefore, enter lidar!

LiDAR is a remote sensing technology that uses light in the form of a pulsed laser to measure the precise distance to an object. Integrated with other various enabling technologies, the final result of a lidar survey is a mass of geo-referenced, precise, accurate, 3-dimensional points representing objects detected in the lidar's line of sight during data collection.

The focus of this paper is to provide airport operators and airport, as well as non-airport professionals an overview of lidar in general, with emphasis on mobile lidar uses aimed at the airport environment and it's many complexities. More specifically, 4 applications are presented and discussed. These include:

- Pavement Management
- Safety and Situational Awareness
- Feature and Asset Extraction and Management
- Engineered Material Arresting Systems Management

Where applicable examples stemming from both mobile and airborne lidar data extracted from 2 surveys of the Peterborough Airport, ICAO CYPQ are presented. The datasets were collected and provided by Optech Incorporated, a leading lidar system manufacturer.

LIDAR DETAILED: WHAT IS LIDAR AND HOW CAN IT BE EXPLOITED?

In general terms, a lidar system (airborne and mobile) consists of a laser rangefinder, a scanner, a Global Navigation Satellite System (GNSS) receiver, and an Inertial Measurement Unit (IMU). A lidar solution can consist of a multiple sensors configuration to increase point density and therefore the ability to gain a better representation of the surveyed object(s). Laser ranges are emitted and reflect off a surface in the line of sight of the lidar unit. Laser ranges are combined with position and orientation information to produce what industry professionals refer to as a 'point cloud'. Post processing and further analysis of this point cloud enables users to extract position and elevation information as well as other relevant information when combined with other sensing technologies such as digital cameras.

Lidar data, in essence is a mass of data points. These points are randomly distributed. Each data point contains position and elevation, or XYZ information. The lidar's return signal is commonly measured and therefore another attribute that is possible to use to extract information is "intensity" Intensity is a measurement of the object's reflectance level. For example grass or white paint lines will return a higher intensity value than asphalt or piles of coal. This means that each return can have a value associated with it based on the "intensity" of the return. The intensity value of any given object will be the same whether collected in daylight or night-time, or no- light conditions as the lidar system is an active sensor and generates its own light. This value in turn can be used to view the point cloud in grey-scale or generate a grey-scale photo-realistic raster image. Figure 1 illustrates the Peterborough airport depicted in grey-scale based on the intensity values using the airborne lidar data. This particular image has been generated with a grid size of 0.75 m per pixel.

With the ability to view intensity data, features that are homogeneous in elevation characteristics can be deciphered. This is demonstrated in the above figure, whereby the paint lines on the runway can be seen. In the elevation only model, or the DEM, the User would not be unable to characterize this type of information.

Lidar data is well suited to fuse with other data sources. Many service providers offer lidar data collection, processing and information extraction whereby other data sources act as additional source of information that allow the User to ensure higher degree of integrity, accuracy and validation of final information output.

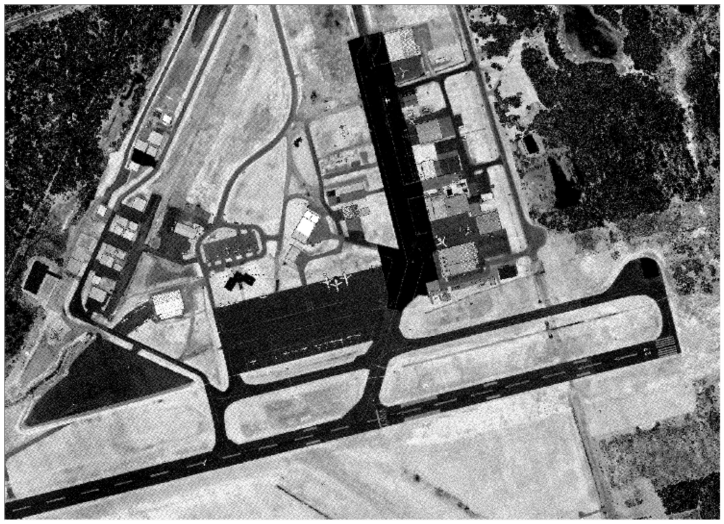


Figure 1. Peterborough Airport grey-scale raster image (courtesy of Optech Inc.).

There are typically three platforms on which a lidar instrument is installed. These are:

1. Airborne

2. Static, or Tripod Mounted.

3. Mobile

Lidar data collected from each type of platform all have applications and uses for the airport and airfield industry.

Airborne

As mentioned, airborne lidar data, collected with aerial imagery (RGB) is now used to identify obstructions in an airport's approach path, as per FAA Part 77. Using specialized software packages, one can relatively easily use the data collected, after a quality control and validation process, from the airborne survey and compare it to the 3D imaginary surface known as the Obstruction Identification Surface (OIS) to get a better understanding of obstacles that need to be managed, i.e. removed, or by including the obstacles in the approach and navigation charts so that they can effectively be avoided on the approach by an aircraft.

Figure 2 illustrates the basic principles of airborne lidar system. In this case, the instrument is mounted in a fixed wing aircraft, though many companies also install lidar units in a helicopter, or rotary, aircraft. Helicopters are often used for corridor mapping based on the ability to easier control the vehicle to make sharper turns, the ability to fly lower to the ground, and to fly slower enabling a much more dense dataset. Additionally, installing the instruments in Unmanned Aerial Vehicles (UAVs) are gaining a lot of traction in the remote sensing, surveying and mapping world.

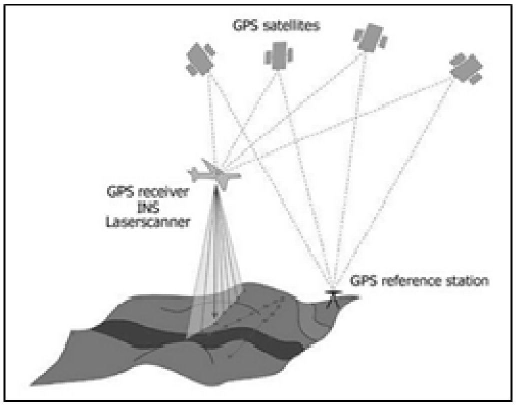


Figure 1. Basic components and principle of airborne lidar mapping [1].

Airborne lidar data is very well suited for wide-area mapping, whereby tens, hundreds, or even thousands of square kilometers can be surveyed in relatively short timeframes with significant detail, with a high degree of accuracy and precision. Other benefits to using airborne lidar, and lidar in general are later presented a separate section.

Airborne lidar-derived models such as the Digital Elevation Model (DEM), also known as bare-earth model, Digital Surface Model (DSM), Digital Terrain Model (DTM), elevation contours, and Level of Detail Two (LOD2) building models are typical outputs.

Airborne lidar data, fused with RGB imagery, and with mobile lidar data for increased resolution and detail of specific areas/objects, is ideal to create a virtual, real-life model of the entire airport. This model could be utilized for many purposes, such as drainage pattern studies, wind and noise studies, Wi-Fi connectivity on the airfield studies, and navigation applications, which will be discussed in some detail in Section 4.0 of this paper.

Static, Tripod-Mounted

Static lidar, also referred to as tripod mounted, or ground-based lidar data is often collected using a standard surveyors tripod. The lidar unit, which is typically much smaller in size than lidar systems built for airborne and mobile platforms, is placed on top of the tripod.

Static lidar can be collected and delivered in a local coordinate system. This means that the data is not referenced in a Cartesian, or real world coordinate system. This is one main difference from airborne and mobile lidar mapping in that a GNNS and an IMU is not required. If the data requires geo-referencing, one could add a GNSS receiver. However, please note that a certain process must be followed to ensure data accuracy and integrity. This, however, is out-of-scope of this paper.

Static lidar is often used for more focused surveys, and where great detail is required. The coverage area is not large, but the detail is great. The resolution of a static lidar is typically greater than those employed in airborne lidar instruments. Due to increased range resolution, along with less impact of environmental interference and slight technology differences, static, and mobile lidar instruments are generally more accurate and precise than data collected using lidar collected in an airborne platform. Additionally, a different class of laser is used in the ground-based lidar units, including the mobile lidar. This primarily and most importantly allows for eye-safe operations. However as lidar systems become more advanced, the separation in capability between airborne and ground-based lidar units is narrowing.

Static lidar systems are well suited for applications such as archaeological site surveys, open pit mine surveys, and as-built surveys.

Further to the applications listed above, static lidar surveys and data produced are gaining fast, and widespread popularity with the Building Information Modeling (BIM) movement. They are very suited to provide the detail and accuracy required for such applications. As new terminal and hangar projects are at the forefront of airport improvement, lidar should be a technology that continues to gain momentum in the airport industry as its advantages become more known and understood.

Figure 3. Tripod mounted Static lidar system [2].

Mobile

Mobile lidar is typically mounted on the rooftop of a vehicle, and generally on a van, truck or SUV type vehicle. The higher the sensors are placed the less likely one will encounter shadowing, which is a derivative of such remote sensing techniques. The sub-systems and components of a mobile lidar unit are essentially the same as an airborne unit. There is one considerable challenge that is not frequently faced from an airborne scenario and that is the ability, or inability, to maintain a quality GNSS solution. Shadowing and multipath due to large buildings, narrow corridors, tunnels, etc contribute to a loss of satellite lock and therefore the ability to compute an accurate position. For that reason, operators must take caution when planning a mobile survey in order to consider optimum GNSS conditions, and any issues that may be encountered.

Mobile lidar data is often simultaneously collected with oblique, stereo RGB imagery. Again, as in the case with airborne and tripod mounted lidar data, the result is high resolution and high accurate data points, from a ground-level perspective. This perspective allows data to be collected in between buildings that are close in proximity, under tree canopies, and under bridges; areas where airborne lidar surveys are unable to see and collect, or are severely limited, at best.

Mobile lidar is extensively deployed in transportation projects; mostly roads and highways, but it also is in widespread use for railroad applications. For many of the reasons why users conduct airborne and/or tripod mounted lidar surveys, mobile lidar systems continue to gain momentum in many industry applications.

With an effectively planned survey, a mobile lidar system can be driven strategically throughout the airfield to collect locations and information about airfield resources, terrain, and structures such as airfield lighting assets, pavement conditions and markings, and used to build models such as a DEM of the airfield, to name a few.

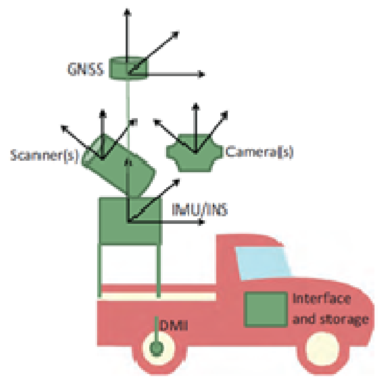


Figure 2. Principle and components of a mobile lidar system [3].

BENEFITS OF USING LIDAR DATA

There are many advantages to conducting lidar surveys and using lidar-derived data and models based on the data in an airport's information system and in the everyday decision-making processes.

Major benefits are listed below:

1. Survey-grade data (in the case of static and mobile lidar).

2. Data collection/survey takes a fraction of time than a survey crew collecting survey points using traditional tools and techniques.

3. Non-intrusive - runway and other areas of the airport require closure for a very short period of time versus other techniques which may require days of runway closure, which quite simply is not an option at most airports.

4. Potential for cost-savings. Fast data collection time, and digital data could lead to increased cost savings over other survey methods.

5. Coupled with its data collection speed, the lidar survey can be conducted at night. As mentioned lidar is an active sensor and creates its own light source. Only caveat is if the operator wants to collect RGB imagery concurrently. If a night-only survey is suitable, the survey crew could cover a lot of ground to conduct pavement condition surveying, avoid peak take-off and landing periods or during runway or airport closure, minimizing overall impact of airport operations.

6. Data can be used for many purposes, other than just the main survey purpose, as discussed in this article.

7. In the case of mobile and tripod mounted surveys, a video source can be connected, time-stamped and reviewed after the fact to validate objects, data integrity, etc. This is a major benefit to the airport users as many objects that can be collected and extracted from mobile lidar data require some form of interpretation.

SPECIFIC USES OF LIDAR DATA IN THE AIRPORT

There are a four specific uses of mobile lidar data that are discussed in the following sections. While it is not possible to go into great detail on each, it is illustrated that lidar can play, and in some instances is playing, a prominent role in each application.

Pavement Management

One application that is gaining a lot of attention in the airfield management industry is the use of mobile lidar data to evaluate the state of the pavement, including the use of lidar to assist in resurfacing efforts [4]. Along with typical analysis such as cross-slope and width measurements, it is possible to create a high-precision surface model whereby pavement cracks can be identified, extracted and managed in a information system, such as a specialized GIS. When coupled with RGB imagery or video, a classification of pavement distress is possible, which would include location, type, quantity and severity.

The accuracy of a mobile lidar system will enable compliance of aGIS deliverables (AC 5300 – 16, - 17, -18) when used with survey control. In some cases, topography can be controlled to less than 2.5 cm, or 1 inch [5]. Recently Woolpert published project details, including some results, whereby 3 airports in the United States utilized mobile lidar to assist in pavement-related management [6] . These applications included the following:

a. Pavement Condition Assessment,

b. Design and Reconstruction of a runway surface, and

c. Inventory and repair of concrete panels (>400, 000 square feet)

Furthermore, as presented the in the recent publication 'Guidelines for the use of Mobile Lidar in Transportation Applications' by the Transportation Research Board [7], several examples of how MLS data can be used to evaluate pavement condition including rutting, ride quality, rehabilitation, texture, and automated distress. It was emphasizes that the acquisition of all of these data from a single, integrated point cloud represents a major paradigm shift for the industry where these data are acquired from a variety of sources.
Scheduled lidar surveys, for example on an annual basis can assist in determining current pavement distress levels and would facilitate airport operators to ensure they are offering safe pavement conditions that are in compliance with civil aviation authority requirements, as well as taking a proactive approach to protecting the investment.

One other potential use of a mobile lidar survey is for validation of a foreign object debris (FOD) radar system to ensure it is functioning in the fashion it is meant to and detecting objects the manufacturers claim it can detect. This can be performed in tandem with a pavement management survey.

Value added features of employing mobile lidar include increased field safety, reduced runway closure times, higher detail - higher resolution accuracy and the ability to extract other features not explicitly intended for on the particular survey (versatility) [8].

Safety and Situational Awareness

Safety is still fundamentally the highest priority in aviation. This is no different in the airports and on the airfield. In the event of an accident involving aircraft, Aircraft Rescue and Fire Fighting(ARFF) vehicles must quickly respond to the incident which may involve tricky navigation to the scene. Driver Enhanced Vision Systems (DEVS) are used to assist the ARFF operators to navigate in low - no visibility conditions. Ideally, the ARFF vehicle is equipped not only with a DEVS system which helps them safely navigate, but also with a hyper-spectral infrared camera that can assist the operators in seeing objects they would typically not be able to see in the low-no visibility conditions, such as fog, heavy rain or snow squalls.

Current DEVS technologies only display in 2D. Therefore, while the ARFF driver can see where they are in relation to other objects on the image or in the CAD/GIS data, the data and information is only visually represented in plan view, or 2D. Consequently, an operator would not know the relief of the topography unless it was represented on the base map somehow. Displaying in 3D addresses this major concern.

In fact with today's software technology, it is possible, with relative ease to generate an accurate and precise 3D virtual model of the entire airport, including buildings, ATC towers, topography, lights, signs, gates, etc. The missing part to constructing models is the data. Lidar is perfectly suited as the data source to create the 3D models. Furthermore, integrating the lidar data with RGB imagery would allow for object texturing which will give the real world appearance of any object.

The following three figures highlight 3D scenes that have been generated using mobile lidar data. The data sets collected for the Peterborough airport survey were used to generate these images. The images are portrayed in 3D perspective view illustrating a more natural human-eye perspective. Each of the figures is displaying the same view-point, but each one is coloured by different attributes; intensity, colour-coded elevation, and rgb-draped imagery. Fusing other GIS layers and imagery would add greater value and information.

Figures 6a and 6b show an integrated dataset of multiple sources. The RGB imagery has been draped on a lidar-derived Bare Earth DEM, with building models derived from lidar data, and paint lines as GIS layers added for additional interpretation and value.

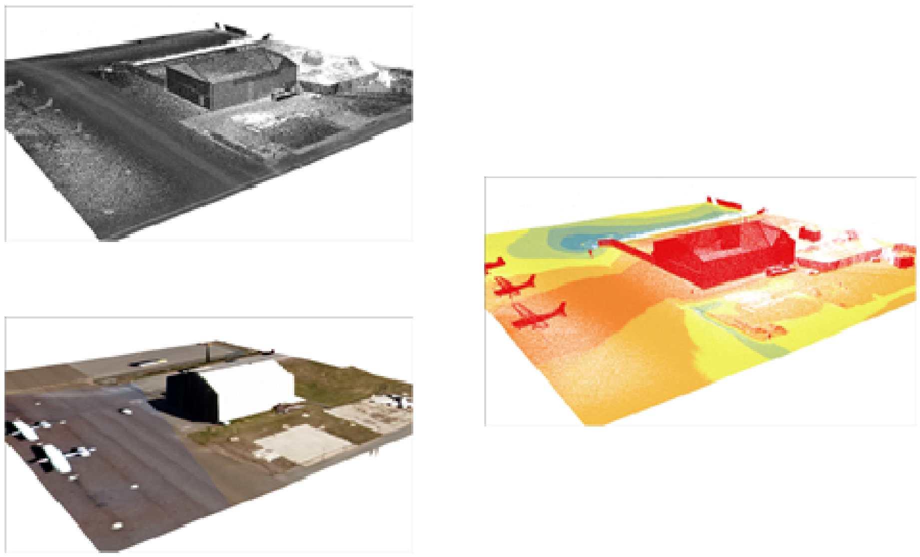
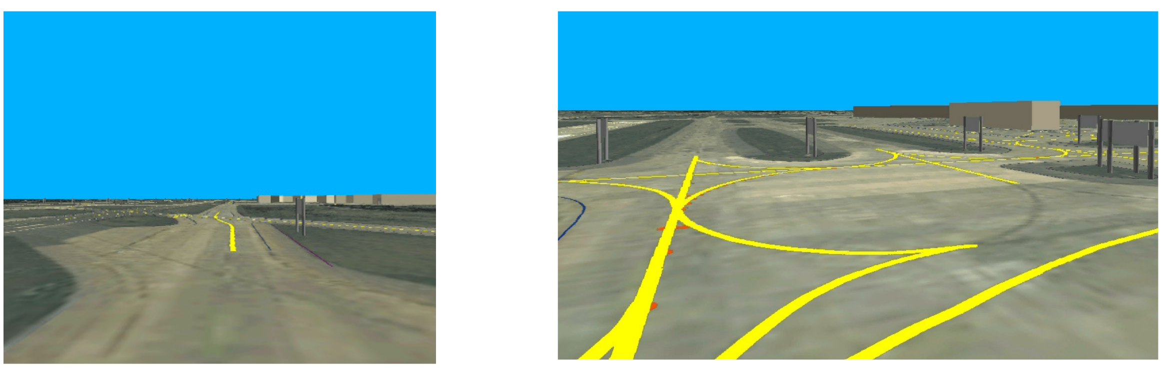


Figure 5. (a) Grey-scale intensity lidar data in 3D perspective; (b) Elevation Colour-coded lidar data in 3D perspective; (c) RGB Imagery draped over Surface model derived from mobile lidar data in 3D perspective.



(a) (b)

Figure 6. Virtual airport model derived from Lidar data, RGB imagery, and GIS feature layers.

Once a comprehensive 3D model exists of the airfield and airports, other uses may include planning and training purposes, including line of sight and view-shed analyses. (These two analysis methods refer to visibility of a region or an object from a given position of the observer.) In the airport industry, the ATC should be able to have unobstructed visibility, by terrain or man-made objects to all regions of the airfield. By having such inputs, such as a DEM, building, etc., derived by lidar data, airport planners can ensure unobstructed “line-of-sight” or visibility during the planning stage of a new ATC location.

Extraction of Features/ Assets

Given the high resolution capability of lidar data, along with it’s accuracy, it is possible to extract many features of an airport/airfield solely using lidar data, or combined with other data sources such as RGB imagery and/or time-tagged video. This section illustrates the use of mobile lidar to extract airport features. While the FAA recommends additional survey techniques, such as the placement of retro-reflectors at each object intended to be extracted, software solutions exist today that can allow semi- or even automatic extraction many features. As with any other surveying techniques, a QA process should always be part of the survey and data extraction process.

This section provides illustration of the following features that were extracted from the mobile lidar survey of Peterborough airport, and stored and represented in a GIS.

The focus areas for this case study include the following:

1. Extraction of runway edge lighting, etc.

2. Extraction of paint lines.

3. Extraction of runway and taxiway outlines.

With more airports using GIS to manage their operations, including airfield inspections, the electrical assets can be stored in the form of a GIS layer and imported into the airport GIS system. The spatial component, i.e. location of each asset can be extracted from the lidar data.

Figures 7 and 8 show, in profile mode, the mobile lidar points of the runway edge lighting. Note the difference in elevation, or height. This allows the lighting to be extracted using common geoproceesing tools and scripting.

Figure 9 illustrates, in perspective view an intensity image, with GIS markers representing each light structure that has been have identified and extracted.

Separate GIS layers can be generated to hold both the geospatial information of each light as well as attribute information for each light, i.e. light type, colour, manufacturer, install date, etc.

Once this type of data is represented in a GIS database, more specific and value added analysis coupled with other data sources can occur. For example, knowing the distribution and frequency of lighting outages can play a big role in the management of the electrical component of the airfield, and therefore potentially increase safety while operating in a proactive fashion.

Figure 7. Cross section profile of mobile lidar illustrating runway and edge lights.

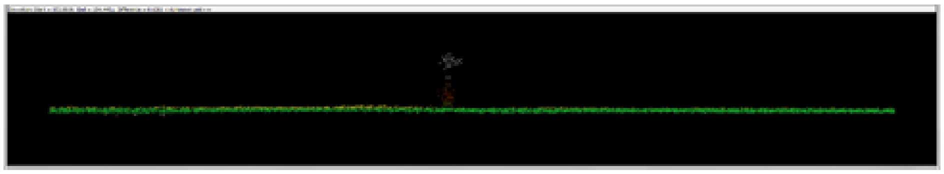


Figure 8. Cross section profile of mobile lidar data of an edge light.

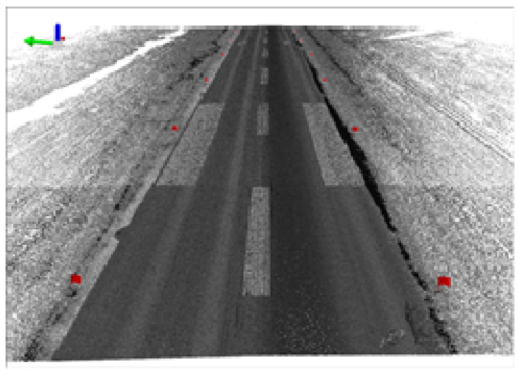


Figure 3. Intensity coloured points with extracted edge lights represented as GIS markers.

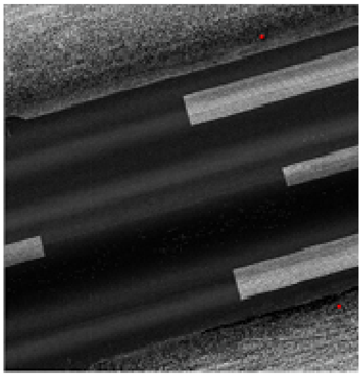
Furthermore it can be used in an electronic airfield inspection software solution whereby GIS and Imagery info is integrated with GNSS to allow for geo-spatially enabled inspections.

Next, the paint lines have also been extracted from the lidar point cloud using intensity analysis. In this case a gridded surface of 5 cm per pixel size was generated. This displayed all lines accurately and allowed the outlines to be manually digitized into a GIS file format. Note that specialized software that is designed to extract features from lidar is available.

There are opportunities to extract a lot of other features within the airfield and airport environment. Items such as signage, light standards, and windsocks can all be identified and extracted from a mobile lidar data set.

Engineering Materials Arresting Systems Management

EMAS is an acronym for Engineered Materials Arresting Systems, and there are currently over 40 airports in North America with EMAS beds. The premise of the EMAS bed is to safely slow down and ultimately stop, or arrest, an aircraft that has overrun the length of the runway, typically in poor weather conditions, whereby the runway safety area does not meet the newer 1000 feet requirement. In airports where there is not enough area for an aircraft to successfully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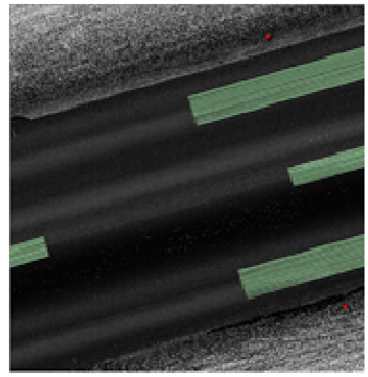

(b)

Figure 10. (a) 5 cm grey-scale raster intensity image derived from mobile lidar data; (b) Paint lines, as a GIS feature layer extracted from the grey-scale intensity raster.

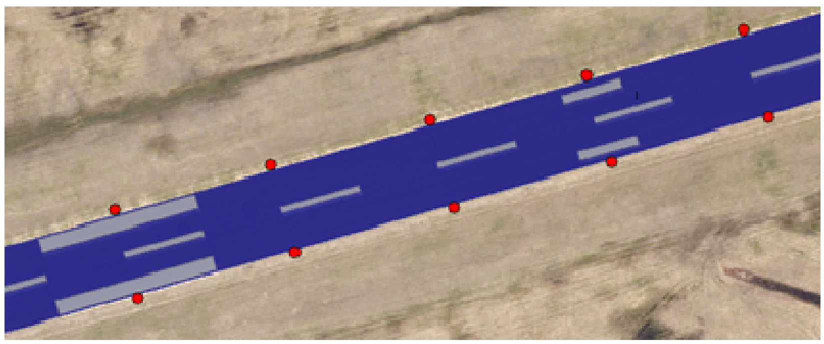


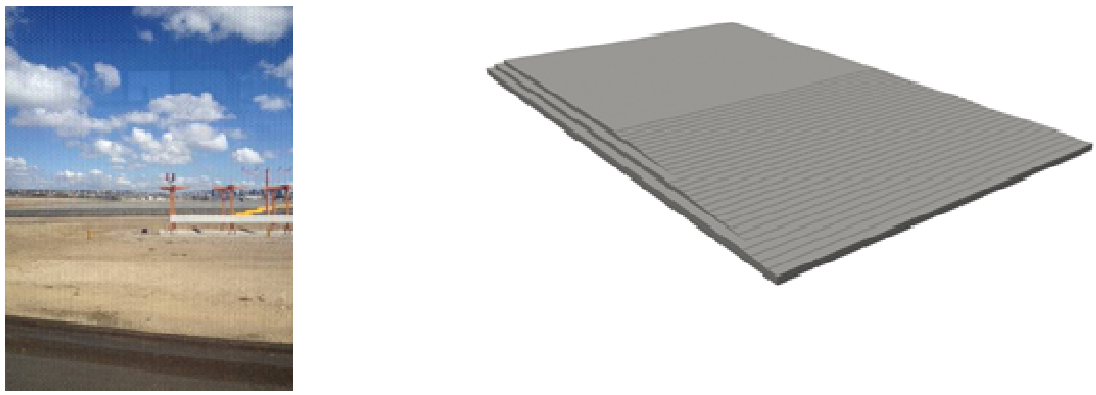
Figure 11. Outline of Runway extracted from mobile lidar data set, overlaid on RGB aerial image.

come to a stop in the runway safety area on its own without the risk of driving into a highway, or over a cliff or rugged terrain, or into a water body, an EMAS is a viable and safe solution.

Utilizing lidar, either mobile or Tripod mounted, is a perfect scenario to better understand the pre-construction efforts (volumetric analyses for example), to baseline precise location of the entire bed, and allow for monitoring over time to ensure no structural damage or displacement occurs due to factors such as jet blast, and for use in general inspections on a daily or weekly basis to ensure the seam seal and or concrete has not been compromised due to environmental factors such as weather and/or large debris, or human factors such as walking on the structure to remove objects or perform an inspection.

By performing a comparative analysis on one model derived from a lidar survey conducted in Year 1 to the baseline model, or Year 0, one could learn of any items that have changed in that year. For example there may be some blocks that may have become “deflated” and therefore may be compromising the integrity and overall effectiveness of the bed were there to be a breach of the runway end surface. This analysis can lead to a better understanding of the structure, and potentially allow for preventative maintenance and advanced design for next generation EMAS solutions. Adding RGB imagery could allow for even further understanding of current conditions of individual blocks, or a certain section of the bed, as it would allow for a visual representation of the surface, on top of the detail surface model derived from the lidar data.

To measure each block in the bed could be a very time consuming task, not to mention that due to its general nature, human error may become more prevalent. Using lidar to survey the surface and surrounding area could produce results that a human might miss or not be able to see. Furthermore, one could conduct the lidar survey and inspect the surface in the office, which adds a further safety component to using lidar for this particular application.



(a) (b)

Figure 12. (a) Image taken of San Diego International Airport's EMAS bed; (b) 3D model of EMAS bed illustrating benefits of having a detailed 3D model derived from lidar data.

CHALLENGES OF WORKING WITH LIDAR DATA

It is important to present this technology objectively. Therefore this section offers some potential challenges of lidar, in general. While potentially problematic, please note that with proper system and survey planning, clear understanding on project requirements, and experienced operators and processors, all challenges listed below can be overcome. The challenges have been broken down into 3 categories.

1. Hardware

2. Data Collection / Survey Planning

3. Data Handling/Processing and Information Extraction

Hardware

Hardware must be properly and accurately calibrated. If the hardware has calibration issues, typically at the sub-system and integration levels, items such as signal strength, receiver alignment, laser power, etc., can and will all have an adverse impact on system reliability and data quality, including final accuracy of the product.

Furthermore, as lidar units become more commonplace, more manufacturers are entering the market. While all lidar systems employ the same or similar sub-systems, it is important to note that it is possible to select systems that are more suited to specific applications, as well as systems that have operating limitations. Therefore it is important to perform your research prior to purchasing a lidar unit or selecting a service provider who will perform the survey(s).

Data Collection/Survey Planning

Considerations for survey planning can be great. It was previously mentioned that GNSS conditions play a big role, especially in mobile surveying. On top of this factor, one must consider such items as traffic, vehicle maintenance, aircraft readiness (including pilots), and weather forecasting and conditions. One main factor to and perhaps the most important is ensuring that the proper lidar settings, and scanner configurations have been considered for the main survey purpose. While lidar data is feature rich and one can extract a lot of unintended information from it, it is still very applicable to ensure that the systems has been configured for the main purpose or objective of the survey, i.e. slower scanner frequency, narrower scan angle and closer to the object (lower flying altitude) to provide higher density of points per square meter.

Service, providers, survey planners and lidar professionals must be knowledgeable and experienced in operation, processing and overall use of lidar technology.

Data Handling/Processing and Information Extraction

When working with lidar data, it is crucial that the User have the right tools to be able to not only visualize the large data sets, but to extract valuable information from the point clouds. Lidar data sets typically come in very high volumes and proper data management is paramount. Otherwise one could easily be overwhelmed. Software to automatically extract data, while improving in recent years, still falls short of the advances of the hardware.

The data points from a lidar unit are randomly distributed. They are not in grid format, as many GIS and photogrammatists are used to working with. This makes it challenging when generating DEMS and other models as many GIS packages are expecting regularly spaced, or gridded, data.

As is the case with most remotely survey datasets, useful extraction requires interpretation of the data. "Most applications require solid surfaces with clearly defined edges, and topologically-structured feature entities (points, lines, and polygons) with comprehensive attribution. The time and effort involved in extracting these features from lidar point clouds is high" [9], which can add to the amount of time to turn-around useful data and information. Though, as the industry mature, robust algorithms and software continue to be very beneficial in this area.

CONCLUSIONS

Accessing lidar data in today's world is not difficult. As airports and aviation authorities look to improve ways to accurately represent today's complex airport, the selection of "broad, versatile" technologies should be part of the overall data collection and use plan.

Lidar in general offers the airport operators a wealth of geospatial, and related, information covering the entire airport ground and areas of interest. It has been identified that there are many opportunities to exploit this type of accurate, precise, three dimensional data. In this paper, specific applications of lidar for the airfield and airport management; specifically, some applications where mobile lidar can add significant value were highlighted.

Applications stemming from pavement management and airfield feature/asset extraction to new proof of concept type application such as EMAS bed management were explored.

Mobile lidar is only now just being realized on a global scale. It is feature-rich, accurate and precise.

It is evident that our airport world can also significantly benefit from the adoption of this state-of-the-art technology. As the need to understand items such as pavement conditions and drainage patterns, and stay current with these issues, and as airports continue to grow in size, operations, and budget, employing lidar surveying and mapping as a tool in the overall improvement plan is evident and crucial for a more effective and efficient result.

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